RHIC SYSTEMS

Power Supplies, Superconducting Magnets, Quench Protection, etc.

7/11/06

RHIC PS Performance Numbers

Average RHIC PS Failure Hours/Week (Peter Ingrassia)

	fy01-fy02	fy03	fy04	fy05	fy06
Avg Fail Hrs/wk	18.28	4.36	3.29	2.4	4

Without last 3 weeks of run Avg fail Hrs/wk =2 for fy 06

MTBF of RHIC due to any PS Failure

	HERA e+p 1996	RHIC Run 4	RHIC Run 5	RHIC Run 6
MTBF_M (hours)	22.3	20.48	30.79	28.23
Number of Problems	238	148	138	109

What would be the %AV of RHIC be if only RHIC ps Failures?

	HERA e+p 1996	RHIC Run 4	RHIC Run 5	RHIC Run 6
AV%	96.6	91.97	97.09	95.03
Number of Problems	238	148	138	109

MTBF of an individual PS Failure

	HERA e+p 1996	RHIC Run 4	RHIC Run 5	RHIC Run 6
MTBF(hours)	29310	19106.33	27989	26339
Number of PS's	1166	909	909	933

What happened the last 3 weeks?

- Temperature and humidity went up
- 300A bipolar p.s.’s FET current sharing problem brought out by higher current running and higher temperatures. Linecrew was required to swap out 300A (IR p.s.). This added to downtime.
- Main p.s. problems mostly attributed to loose connections and high humidity (PFN faults)
- QPA IGBT card problems-manufacturing defects of capacitors

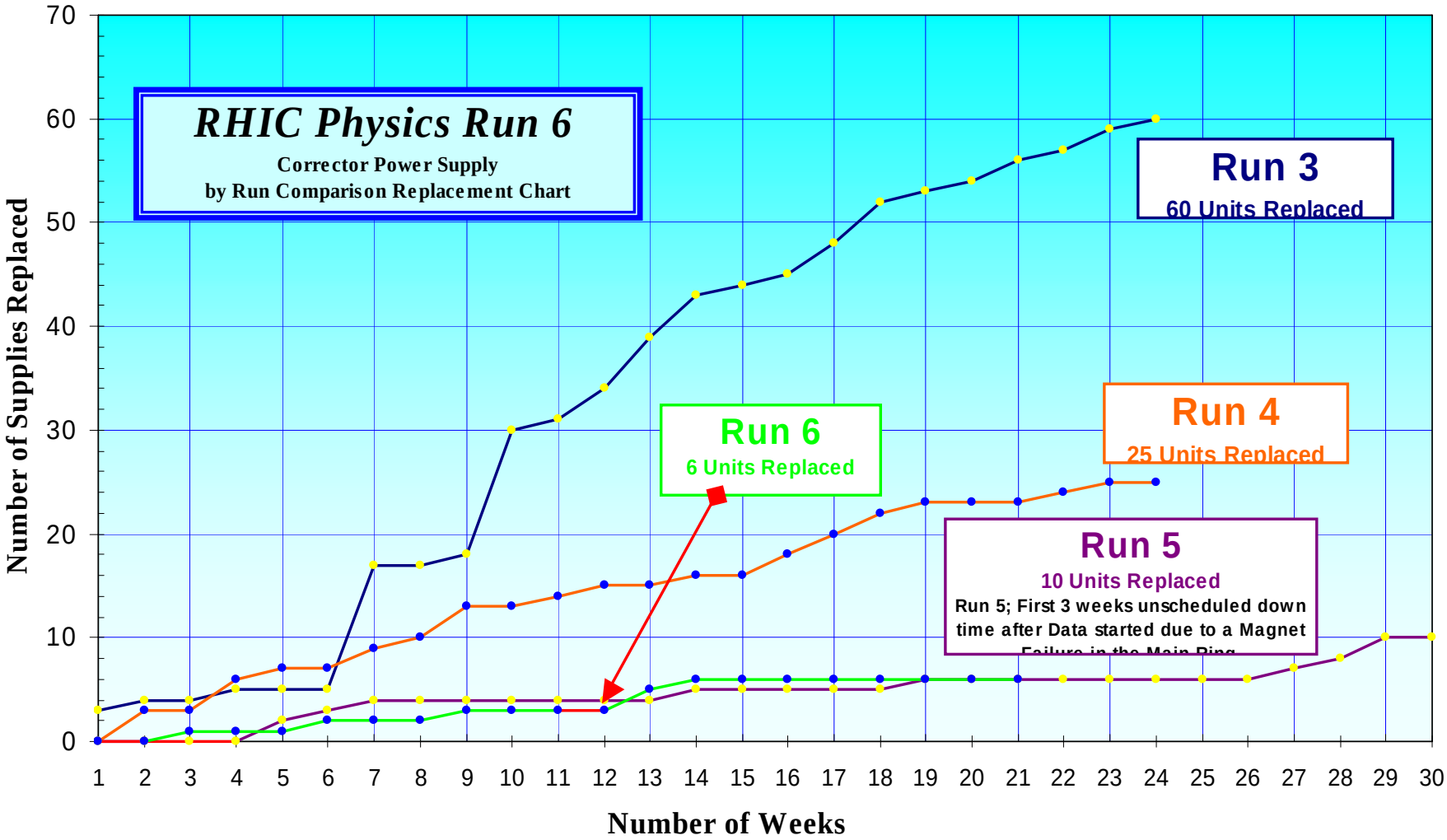
Power Supply and other Systems Performance for Run 6
Run to Run Comparison

Main QLI Faults	RUN #	Run 2	Run 3	Run 4	Run 5	Run 6
Beam Induced	Runs 1 & 2	46	69	54	37	18
Quench Detector Faults	No Data	13	29	13	20	2
Quench Detector / Controls CFE	Available	New Field added starting with Run 6				10
IR Supply Faults		100	44	24	51	29
QPA Faults		40	6	9	6	5
Main PS (Total) Faults		68	38	46	6	14
Controls 6B Yellow Permit Fail		25	9	24	0	0
Controls Related		20	15	20	13	5
Operations Error		34	15	17	12	4
Cryo Related		6	9	2	4	2
Power Failure		10	8	3	7	9
Other		27	27	24	29	9
Power Supply Induced Quench		6	1	4	0	0
Totals:	1197	395	270	240	185	107

Power Supply and other Systems Performance for Run 5
Run to Run Comparison

Snake / Spin Quench Faults	Run 2	Run 3	Run 4	Run 5	Run 6
Beam Induced	20	17	5	2	3
Controls Related	New Field added starting with Run 6				9
Quench Detector Faults	0	0	1	0	2
Quench Detector / Controls CFE	New Field added starting with Run 6				1
Power Supply Faults	10	2	4	0	1
QPA Faults	0	0	0	0	0
Operations Error	2	0	2	1	2
Cryo Related	2	0	1	3	3
Power Failure	0	0	2	2	9
Other	2	6	0	5	0
Totals:	36	25	15	13	30

Corrector P.S.'s Replaced for Runs 3-Run 6



Corrector PS problems in Run 6

- 3 tripped on OT's because of shorted bypass caps, one of these also had some 2 output FETs that failed.
- 1 tripped on an error fault because the FET's in the negative stage failed as well as the driver chip.
- 1 was removed because it was tripping on an error signal and a bad solder connection was found on the comp board.
- 1 was removed because we happened to find one cooling fan was broken.
- **Summary: 6 explained hardware failures.**

Power Supply and other Systems Performance for Run 6
IR Power Supplies

	Run 3	Run 4	Run 5	Run 6
SCE 150	14	2	9	6
SCE 300	6	1	2	7
Dynapower	2	1	1	0
Dyn Aux Contacts	10	19	0	0

SCE Bipolar 300A IR PS Problems During Run 6

- Three failed on error flt. S/N 1 accounted for 2 of these failures. Blown output FET's were found here in these failures
- Three failed because they were oscillating at high currents causing the quench detector to trip the link. S/N 6 accounted for 2 of these failures. Current sharing of FETs and blown FETs were problems here.
- One spare failed because control power was missing but this could not be reproduced on the bench however the p.s. would not run at high current-converter board replaced.
- Implementing the FET warning circuit here would be a big help here. Improved testing procedures also.

SCE Bipolar 150A & Dynapower PS Problems

During Run 6

SCE 150A Power Supplies

- 1-error fault–could not reproduce, may have been current regulator card
- 2-off trips-bypassed undervoltage circuit
- 1-error fault- no current output-converter board replaced
- 2-ac phase fault. Have not been looked at yet.

Dynapower Power Supplies

- None Replaced.

Main Power Supply problems Run 6

- YMQ had 5 PFN Faults (found loose wire and bad relay), 2 Reg Errors (loose 24V?), 3 Current Monitor faults, 1 DCCT Relay error
- BMQ had a Reg Watchdog (loose 24V?- cycled 110VAc breaker) and Current monitor fault
- BMD had a Current monitor fault

RHIC Snakes and Rotators Problems Run 6

- Q.D.’s loss of communications (including cryo write server)**-Quench detectors placed on their own Virtual Network to help fix this.**
- **Sensitivity to ac power disturbance**

Some other problems Run 6

- Cable between p.s and QPA's These trips totaled about 7 trips. We did find a bad D connector ribbon cable. We must look at others-wiggle tests
- 7 qpa faults – 1 Controller Card, 3 fan switch bypass jumper, 2 bad fans, 1 energy extraction resistor in circuit always.
- 29 qpa fan switch bypass jumpers installed during the run on based on measurements we did while running which prevented many more QLI's.
- Buffer cards- 3 cards, shorted bypass caps and resistor out of tolerance
- Current reg card relays – 7 cards found with bad relays
- 3 p.s.'s had off trips problems which were fixed.

Quench Detector Problems Run 6

- 9 trips due to loss of communication (including cryo write server)**-Quench Detectors placed on their own Virtual Network to help fix this.**
- 1 trip due to calibration channel failure
- 1 trip due to wrong channel assignment (3c-qd1)
- 1 trip due to radiation
- 1 trip due to loose volt tap wire
- 1 trip due to cable between permit module and Q.D.
- 1 trip due to UPS failure at 1002B

Ice ball System Problems Run 6

- 2 one wire temperature sensors replaced
- 4 separate locations had breaker trips (2 in the triplets and 2 on rotators) all due to thermostat leakage current failures. Four Thermostats replaced.
- A low temperature alarm came up. 1 Heater failed and was replaced.

AGS Cold Snake Problems Run 6

- OFF trip of Helical-fixed
- Error trip of Solenoid-fixed
- Solenoid QPA fan switch bypassed-fixed.
- Quench Detector Communications problems-Now Q.D.’s on their own Virtual Network
- AGS cold snake was quenched for the first time during operations because the QD was re-booted while the magnet was at current. Warnings installed to prevent this now.

Work Planed for Summer 06

IR and Corrector Power Supplies

- **New Relays for current regulator cards**
- Performing wiggle tests on ps-qpa that tripped without faults
- **Replacing bad capacitors in IGBT cards of QPA's**
- **Removing all 300A p.s.'s to check current sharing of FET's and going through a more detailed checkout of these p.s.'s**

Work Planed for Summer 06

- Check all insulation displacement connectors on QPA's while IGBT cards being removed
- Removing correctors that failed megger test before run 6.
- Removing correctors with broken fans
- **Install new sextupole p.s.'s**
- **Transient protectors and line filters for snakes**
- **ATR line watermat warning change and watermat fix**
- **ATR line magnet one wire temperature sensors**

Main Power Supplies Work Summer 06-all

- Replace the Isolation Chassis power supplies.
- Rewire clamp type connectors that have multiple wires in them.
- Tighten connections in PFN voltage sense circuits.
- Diagnostic circuits for PFN system.
- Test and if possible upgrade operating systems on computers.
- TAPE modifications

Main Power Supplies Work Summer 06 (cont'd)

- YMQ Current sharing bank 2 and PFN voltage failure check
- BMD Current monitor trip after a quench
- OCC output filter testing for high frequency resonance.

Work Planed for Summer 06

" ICE BALL" Prevention

- Have had 4 GFI trips at triplet magnets and rotator magnet trees because of the way the thermostat is mounted. 3 last year. We think this can be fixed with a new type of GFI but there probably is no time or manpower to do this. *However, if there is time insulators will be added to the thermostats on the triplets and rotators and this alone could fix the problem. This will have a lower priority than the new sextupole p.s.'s*
- Improvements to heaters and thermostats installed on valve box leads could be done but will be left alone for now.

Work Planed for Summer 06

Quench Detector Hardware - Simple mechanical maintenance. Replace temporary connection to the helical magnet voltage taps with the permanent design if there is time otherwise this setup is working.

Quench Detector Server – Server upgrade.

Quench Detection Software – Minor software work.

Quench Detection Tuning –Data taken for improving tq tuning past 30A, is it required for next years run?

Quench Protection Switches – Perform maintenance on all 6 KAmp mechanical interrupter and tighten all connections.

Work Planed for Summer 06

New Software and Software Modifications

- Some improvements in cryo write sever could be done.
- Q.D. UPS monitoring that will have alarms and give correct direction to operations when AC power is lost on critical systems.
- Voltage monitoring production software to be written and tested.
- Continued improvement of automatic qli analysis program-add beam loss monitors – Ongoing process.
- Add mains to snapshot.
- TAPE check if links are up before trying to turn on main p.s.’s
- Installing New Sextupole p.s.’s
- Corrector Lead Voltage Monitor System - lower priority.

END

Work done before run 6 and other information if needed

Work Done Before and During Run 6
Power Supplies

Corrector Power Supplies

- 16 correctors removed to clean DCCT pins
- All Voltage Monitoring removed before Run 6 because of strain relief too tight
- Found some correctors failed megger tests. About 7 repaired. 22 to still fix. These 22 were not a problem during run 6
- Tightened all AC connections
- Tightened all DC connections at CQS magnet trees
- Re-installed voltage monitoring boards in sector 1

Work Done Before Run 6
Power Supplies

IR power supplies

- All 150A and 300A bipolar units had resistor checked in soft start circuit checked. One 150A resistor and one 300A resistor had to be replaced.
- All Dynapower units were checked for loose wires (last year a loose gate drive wire caused a lot of downtime). All connections were tightened. Other problems found and fixed. No Dynapowers replaced in run 6.
- Added covers to ac connections of dynapowers. Barriered iso amp board on stand alone p.s.'s

Sextupole P.S.'s

- No work done on sextupole p.s.'s

Work Done Before Run 6
Power Supplies

Main Power Supplies

- Tightened all connections
- Replaced batteries in UPS's
- Spliced wires, removed pigtails
- Added instrumentation to monitor gate current of OCC Quench SCRs. This will detect an abnormal condition and report to the control system.

Work Done During Run 6
Power Supply Software Modifications

- Improved Automatic QLI program
- Beam abort automatic program checking for p.s. faults added.
- Would like to add beam loss monitor data to automatic QLI program next.

Work Done Before and During Run 6
SC Magnets

- Blue sector 12 Q6 shunt bus has an 83 μΩ resistance when powered to 120 A during the proton 205 GeV test. Added one additional voltage tap during the summer shut down of 2005 to try to locate the high resistance to a smaller group of magnets when we get cold in the fall.
- Hi-Pots of Magnets done but none had to be cleaned this time. Rework sextupole ceramic lead tefzel insulation to prevent low resistance to ground problems still needs to be done.

Work Done Before and during Run 6
Quench Protection

- **Quench Detector Hardware –** Cleaned air filters. Checked all wires to make sure they were tight but some were missed, one of these caused a problem. All will be checked again.
- Quench Detectors placed on their own Virtual Network.

Work Done Before and During Run 6
"Ice Balls"

- No new work was done here but new heaters will be added to triplets this year.
- We had problems with more C.B. trips due to thermostats failing so we would hi-pot, find the bad thermostat, and replace it.

AGS Cold Snake

- The AGS cold snake Helical was run at 338A maximum and the Solenoid was run up to 300A maximum.
- There were problems with OFF trips on the Helical which was fixed and error trips on start of ramp up for Solenoid which should be fixed.
- No new work planned.

Other work we want to to during Summer 06 but probably won’t get to.

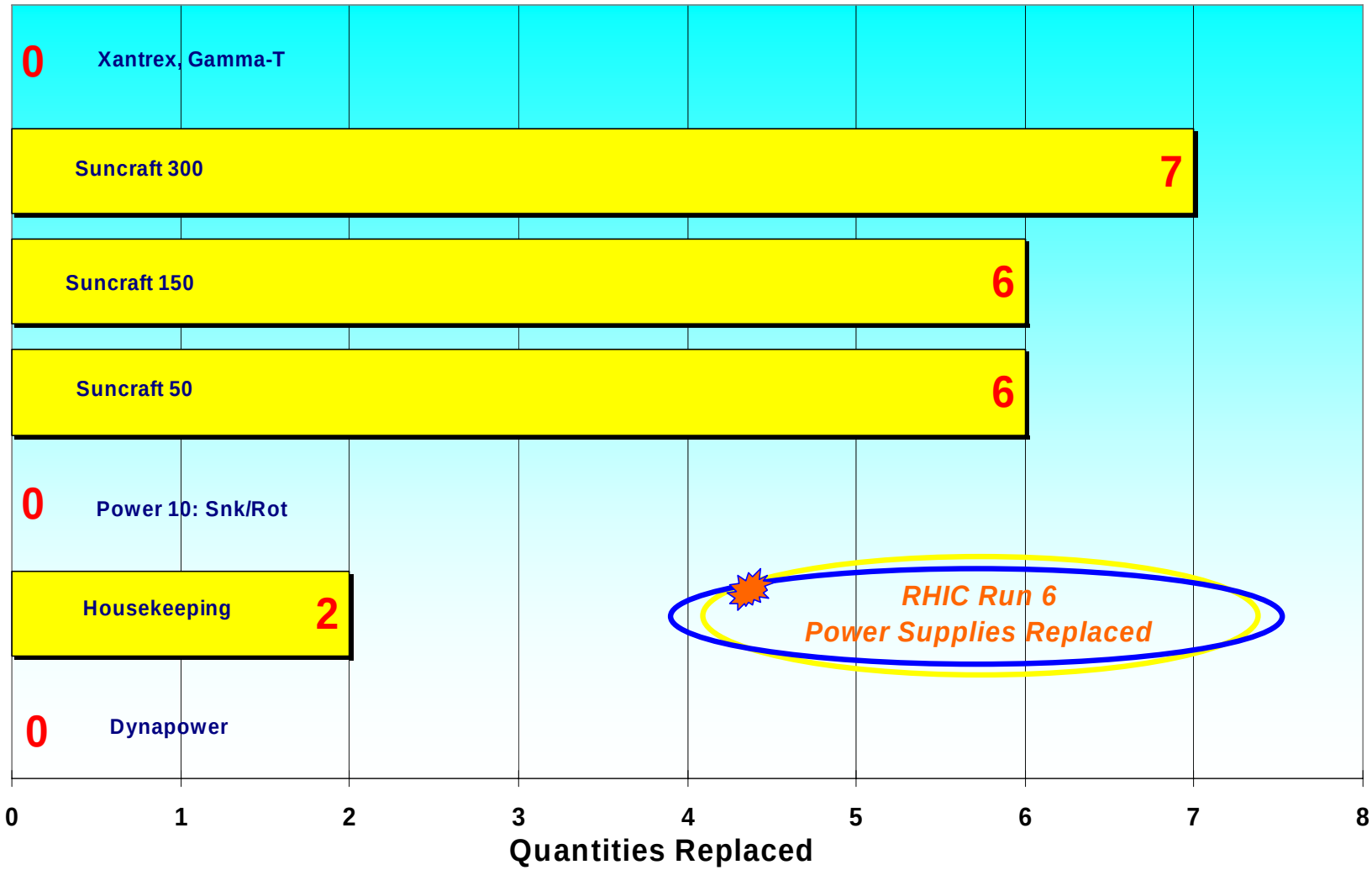
Work Planed for Summer 06

Corrector Lead Voltage Monitor System

- Finish Installing new 1-Wire voltage monitor boards at each CQS and triplet corrector lead.
- There will be 492 boards.
- Each board can monitor 4 signals.
- The system monitors the total voltage across a magnet circuit right at the room temp. end of the gas cooled leads.
- When the magnet current is DC (Not ramping) the voltage measured is then the lead voltage.
- This system will allow, for the first time, a way to measure the performance of these gas cooled leads. This can lead to operational flexibility when there is a low flow condition.
- The final goal for this system is to develop a corrector lead interlock system that is independent of the cryo lead flow .

Charts

P.S.'s Replaced for Run 6



Power Supply and other Systems Performance for Run 6
QLI Counters

QLI Counters for 2005-2006 Run			
Beam Induced	18	Quench Detector Faults	2
IR Supply Faults	29	QPA Faults	5
Main PS Faults	14	Q.D. / Controls CFE	10
Controls 6B Yell. Permit	0	Controls Related	5
Operations Error	4	Cryo Related	2
Power Failure	9	Other	9
Maintenance Related	0	Power Supply Induced	0
Snake & Spin Rotator	Detail	AGS Cold Snake	Detail
		Total	107

RHIC Snake and Rotator QLI's Run 6

2005 -2006 Snake & Spin QLI Counters			
Beam Induced	3	Quench Detector Faults	2
Power Supply Faults	1	QPA Faults	0
Operations Error	2	Cryo Related	3
Power Failure	9	Other	0
Maintenance Related	0	Q.D. / Controls CFE	1
Controls Related	9	Total	30

AGS Cold Snake QLI's Run 6

2005 -2006 AGS Cold Snake QLI Counters

Beam Induced	0	Quench Detector Faults	0
Power Supply Faults	9	QPA Faults	1
Operations Error	3	Cryo Related	0
Power Failure	1	Other	0
Quench Heaters	1	Q.D. / Controls CFE	2
Controls Related	0	Total	17

MTBF DETAILS IF NEEDED

What is the average time RHIC can run before experiencing any PS Failure?

$$MTBF\_M\ RHIC = \frac{MT}{NOF}$$

	RHIC Run 4	RHIC Run 5
MTBF_M (hours)	20.48	29.82
Number of Problems	148	130

The bigger the MTBF_M number is, the better we are doing.

How does this MTBF_M compare with other labs machines?

	RHIC Run 4	RHIC Run 5	HERA e+p 1996	Doris 1996	Entire DESY
MTBF_M (hours)	20.48	29.82	22.3	61	9.2
Number of Problems	148	130	238	87	574

If you ignore all other failures in the machine, except for ps failures, what would be the %Availability of the RHIC machine.?

$$AV\% = \left[\frac{[MT - (NOF \times TOR)]}{MT} \right] \times 100$$

	RHIC Run 4	RHIC Run 5
AV%	91.97	96.9
Number of Problems	148	130

How does this %AV compare with other labs?

	RHIC Run 4	RHIC Run 5	HERA e+p 1996	Petra 1996	Entire DESY
AV%	91.97	96.9	96.6	98.7	91.9
Number of Problems	148	130	238	87	574

What is the average time an individual P.S. can run before experiencing a Failure?

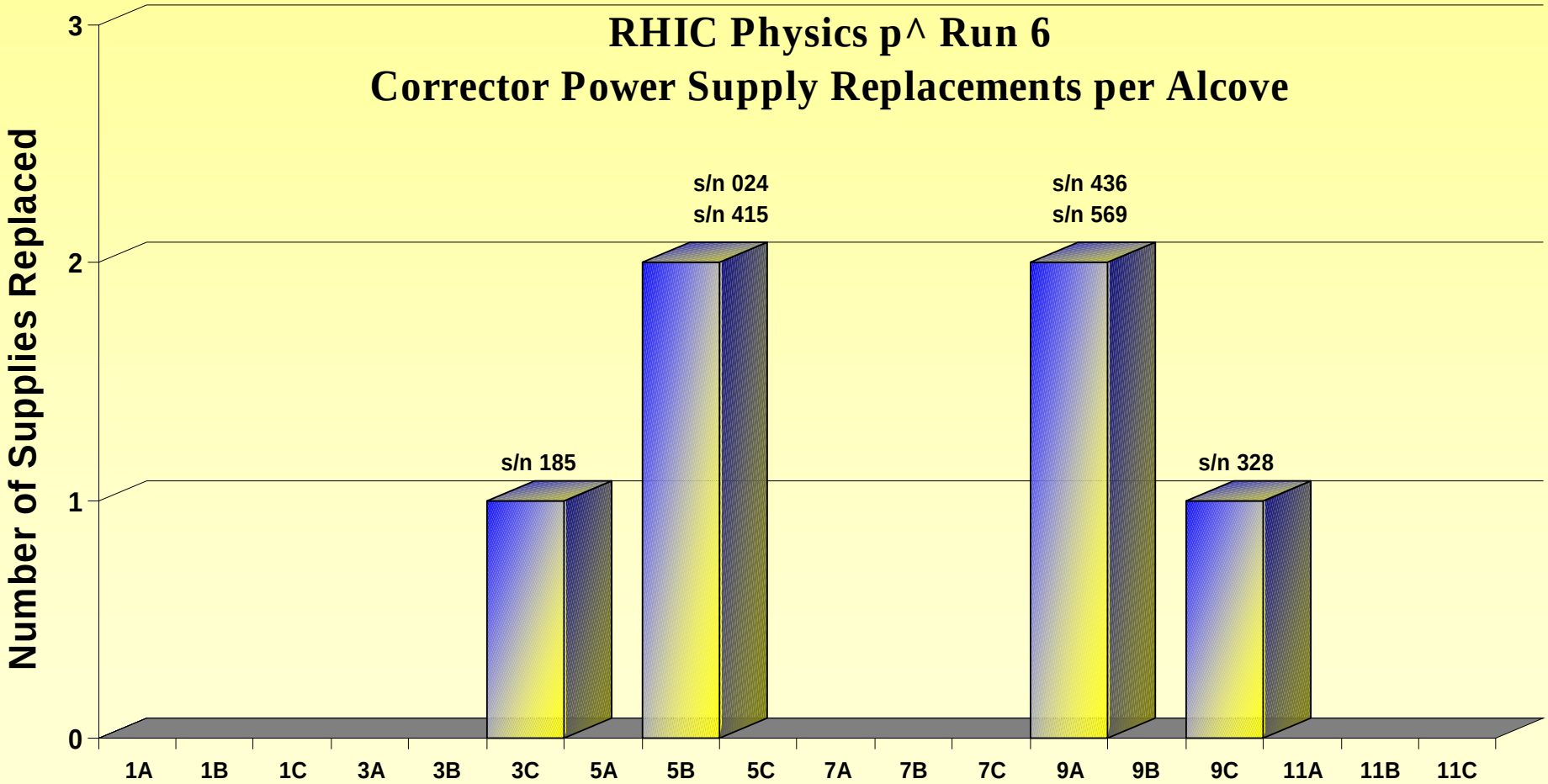
$$\text{MTBF\_Power Supply Systems} = \left[\frac{(\text{MT x NOPS})}{\text{NOF}} \right]$$

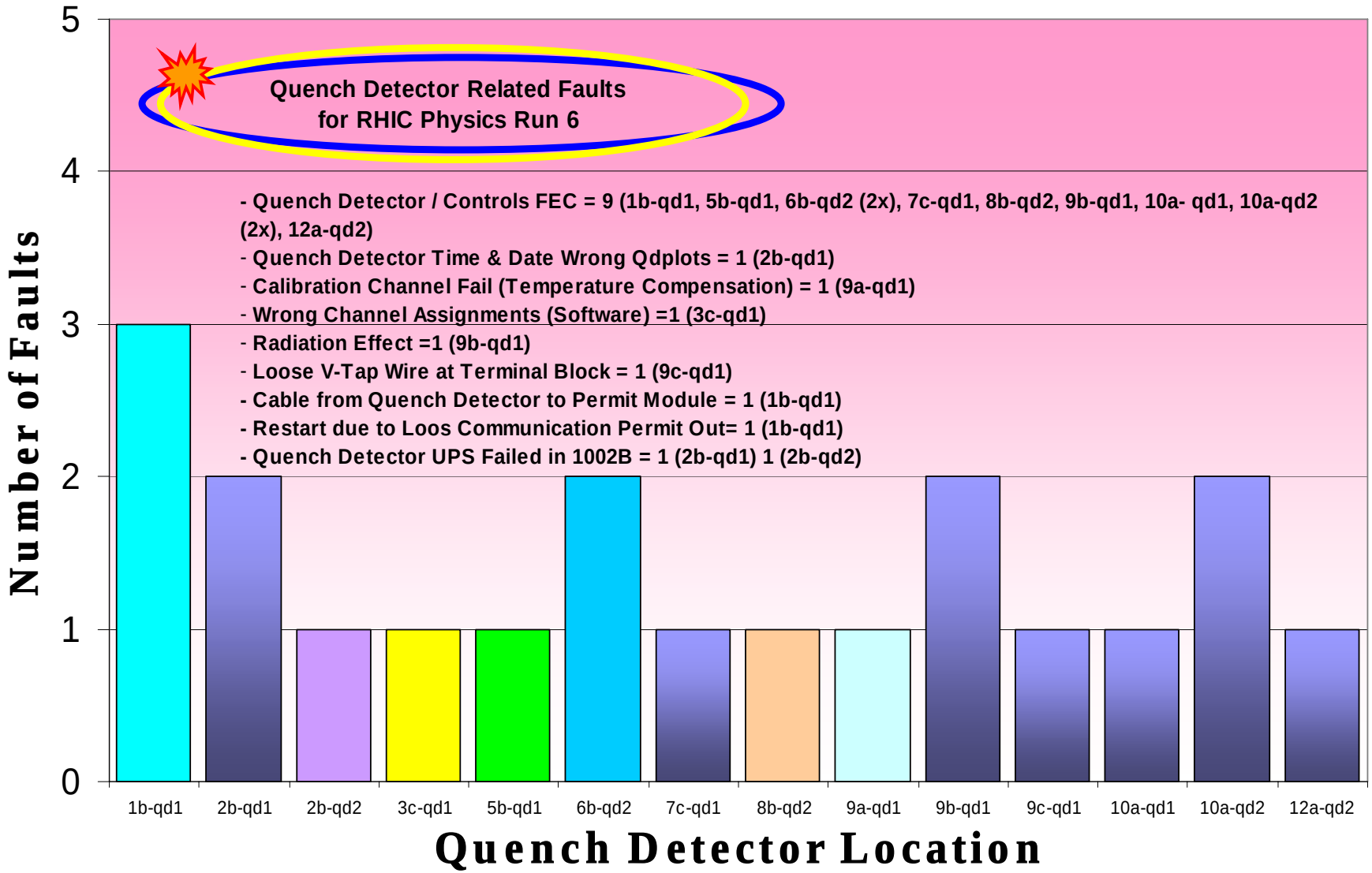
	RHIC Run 4	RHIC Run 5
MTBF(hours)	19106.33	27823.85
Number of PS's	933	933

How does this MTBF_PS SYSTEMS compare with other labs?

	RHIC Run 4	RHIC Run 5	HERA e+p 1996	Doris 1996	Petra 1996
MTBF(hours)	19106.33	27823.85	29310	8968	13988
Number of PS's	933	933	1166	93	269

Charts


RHIC Physics p^ Run 6
Corrector Power Supply Replacements per Alcove
Number of Supplies Replaced
3
2
1
0
s/n 185
s/n 024
s/n 415
s/n 436
s/n 569
s/n 328
1A
1B
1C
3A
3B
3C
5A
5B
5C
7A
7B
7C
9A
9B
9C
11A
11B
11C


Quench Detector Related Faults
for RHIC Physics Run 6
- Quench Detector / Controls FEC = 9 (1b-qd1, 5b-qd1, 6b-qd2 (2x), 7c-qd1, 8b-qd2, 9b-qd1, 10a- qd1, 10a-qd2 (2x), 12a-qd2)
- Quench Detector Time & Date Wrong Qdplots = 1 (2b-qd1)
- Calibration Channel Fail (Temperature Compensation) = 1 (9a-qd1)
- Wrong Channel Assignments (Software) =1 (3c-qd1)
- Radiation Effect =1 (9b-qd1)
- Loose V-Tap Wire at Terminal Block = 1 (9c-qd1)
- Cable from Quench Detector to Permit Module = 1 (1b-qd1)
- Restart due to Loos Communication Permit Out= 1 (1b-qd1)
- Quench Detector UPS Failed in 1002B = 1 (2b-qd1) 1 (2b-qd2)
Number of Faults
0
1
2
3
4
5
1b-qd1
2b-qd1
2b-qd2
3c-qd1
5b-qd1
6b-qd2
7c-qd1
8b-qd2
9a-qd1
9b-qd1
9c-qd1
10a-qd1
10a-qd2
12a-qd2
Quench Detector Location

RHIC Performance numbers without last 3 weeks of the run

Average RHIC P.S. Failure Hours per Week (Peter Ingrassia)

fy01-fy02	fy03	fy04	fy05	fy06
18.28	4.36	3.29	2.4	2

MTBF of RHIC due to Power Supply Failure

	HERE e+p 1996 (comparison only)	RHIC Run 4	RHIC Run 5	RHIC Run 6
MTBF_M (hours)	22.3	20.48	30.79	40.02
Number of Problems	238	148	138	62

What would be the %AV of RHIC if only RHIC PS Failures

	HERE e+p 1996 (comparison only)	RHIC Run 4	RHIC Run 5	RHIC Run 6
AV%	96.6	91.97	97.09	96.74
Number of Problems	238	148	138	62

MTBF of an Individual Power Supply System Failure

	HERE e+p 1996 (comparison only)	RHIC Run 4	RHIC Run 5	RHIC Run 6
MTBF (hours)	29310	19106	27989	37338
Number of P.S.'s	1166	909	909	933